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Thinking critically about critical thinking: Assessing critical thinking of business students using multiple measures

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ORIGINAL AND APPLIED RESEARCH

Thinking critically about critical thinking: Assessing critical thinking of business students using multiple measures

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ABSTRACT
Critical thinking is a skill that potential employers expect all graduates to possess. Hence, most business management programs consider critical thinking as an important student learning goal. Unfortunately, there is ambiguity about how to best assess critical thinking, both as a skill and a learning outcome. The authors empirically demonstrate how they measure the critical thinking ability of their students in different settings, and how their critical thinking ability improves as they progress through the business program.

KEYWORDS
Assessment; assurance of learning; business education; critical thinking; management education

Introduction

Critical thinking can be considered the foundation on which all decisions should rest and is a skill that potential employers expect new graduates to possess (Burbach, Matkin, & Fritz, 2004; Pithers & Soden, 2000). For these reasons, most degree programs consider critical thinking to be an important learning goal for their students (Burbach et al., 2004; Ennis, 1993; Greenlaw & DeLoach, 2003; Pithers & Soden, 2000; Williams, 1999). It is commonly incorporated into course objectives and is assessed with various learning outcomes. Unfortunately, a number of recent reports and books have suggested that college students are not improving their skills in critical thinking. In their recent book, sociologists Arum and Roksa (2011) reported that students "are only minimally improving their skills in critical thinking, complex reasoning and writing during their journeys through higher education" (p. 35). Similarly, another study by Blaich (2007) and the Wabash National Study of Liberal Arts Education, found that students made no significant improvement in critical thinking skills during their first year in college. Arum and Roksa also reported that business majors had the weakest gains during the first two years of college on a national test of writing and reasoning skills called the Collegiate Learning Assessment. They found that compared with business majors, humanities, social science, science, and engineering students saw much stronger improvement. According to them, the limitation of the business students in writing and reasoning skills are attributable to two factors: lack of time on task and the heavy dependence on group assignments in business courses.

While individual business management programs can re-evaluate the time spent by their students in reading and writing, many programs consider the group assignments as a critical element of management education. They argue that managers need to function in groups; hence, a management education without such experience would be incomplete.

Despite the debate about the below-par performance by business majors in standardized tests on critical thinking and complex reasoning, business programs must design an assessment program to evaluate these critical skill sets. Several researchers including Athanassiou, McNett, and Harvey (2003) and Smith (2003) have made significant contributions to this effort. In this article, we demonstrate how we implemented a multimeasure assessment process of critical thinking that provides feedback to our students thereby helping them sharpen their critical thinking skills.

In the next section, we provide a brief review of the literature on how critical thinking is viewed and measured in higher education. This section will be followed by an overview of the literature on critical thinking in management education. Here we discuss examples of a number of models or approaches to

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assess critical thinking. Next, we outline the method we have developed to assess critical thinking. Specifically, we describe the exercises, the data coding and data collection procedure. This is followed by a discussion of the results. We provide statistical test results to demonstrate significant improvement in our students' critical thinking abilities. Finally, we highlight the implications of our research findings and the limitations of our study.

Literature review

Critical thinking has been discussed and contemplated in education circles for many years and is one of eight goals for schooling in a list generated by policy makers and educators (Tempelaar, 2004). The eight broad goals for schooling in the United States are basic academic skills, critical thinking and problem solving, social skills and work ethics, citizenship, physical health, emotional health, arts and literature, and preparation for skilled employment. Business education addresses several of these areas, including critical thinking and problem-solving skills. However, despite these policy directives, teachers continue to struggle with how to engage students in critical thinking activities and students seldom use critical thinking to solve complex, real-world problems. Part of the problem is that students are taught "what to think" rather than "how to think" (Smith, 2003). Moreover, students are expected to learn without being taught anything about learning skills. The process of how students learn is important. For example, Schamel and Ayres (1992) suggested that students learn best by preparing their own questions based on their observations rather than by participating in an exercise with a foregone conclusion.

Because success in our technically advanced society requires critical thinking competence, and because education is the principal means of preparing students for an active and responsible life, it is imperative that schools at all levels focus on fostering and developing of critical thinking skills (Costa, 1991). According to Nelson (1994), enabling a student to think critically is one of the central objectives of liberal and physical education. It calls upon students to evaluate their own thought process and involves a movement toward inquiry- or problem-based learning.

Predictors and correlates of critical thinking skills

Facione (1990) reported that there exists a weak relationship between critical thinking skills and disposition and that there is a need for both of these to be a part of the curriculum models. In a study of 193 students in Grade 10, it was found that there exists a positive correlation ($r = .41$) between California Critical Thinking Disposition Inventory and California Critical Thinking Skills Test scores. Critical thinking accounted for 16.8% of the variance in critical thinking disposition and vice versa. Facione et al. (2001) conducted a five-year longitudinal investigation of 7,926 students from 50 different college level programs to identify the relationship between critical thinking skills and disposition, as well as other demographic factors. They found a positive correlation between overall disposition and strength of critical thinking. This study also looked at each of the subscales and found significant correlations among most of them, except for a relationship among critical thinking, self-confidence, and awareness and a relationship among critical thinking, self-confidence, and evaluation. Torres and Cano (1995) conducted a study on 92 agricultural seniors to test the relationship between learning styles and critical thinking. Age, gender, and GPA accounted for 13% of the critical thinking variance and learning styles accounted for 9% of the variance in senior students' ability to think critically.

Critical thinking in business schools

Effective thinking is a key to management success because it is involved in virtually every task or function a manager performs (Smith, 2003). People who think critically are able to challenge the accuracy of what they hear and read (Ennis, 1993). They are able to consider the setting in which information is obtained (Halpern, 1998), are open minded (Ennis, 1993) and analytical (Halpern, 1998), and are able to interpret and analyze information in a variety of settings (Halpern, 1998). In addition, critical thinkers are able to evaluate the credibility of information (Ennis, 1993), infer consequences flowing from a decision (Halpern, 1998), and justify their reasoning effectively (Ennis, 1993).

Unfortunately, studies done by several governmental agencies (e.g., National Commission on Excellence in Education, 1983; U.S. Department of Education, 1990) have found that most students at all levels are unable to think effectively and cannot understand challenging texts or complex issues. Their reasoning is illogical, they do not critically assess arguments, and they solve problems in a rote manner. This concern was echoed by the Accounting Education Change

Commission (1990) and they urged business schools to develop programs that will improve students' higher-order thinking skills. High level thinking skills involve reasoning, problem solving and decision making.

Business schools address this issue by teaching students to think critically and by offering courses in managerial decision making. A few schools may include critical thinking courses in their curricula. Business school professors integrate critical thinking material into their content area coursework. They foster in-class discussions and projects and provide open-ended exam questions, exercises, and cases at the end of the chapters. Major topics are elaborated on and taught in the form of concept, principles, strategies, methods, heuristics, and skills. For example, Athanassiou et al. (2003) used a metacognitive framework based on Bloom's Taxonomy (Bloom, 1956) to build students' critical thinking and synthesis skills. Clabaugh, Forbes, and Clabaugh (1995) used case studies to develop critical thinking skills in a professional selling course. Ronchetto and Buckles (1994) taught total quality management techniques to promote critical thinking in a service-marketing course. Similarly, Page and Mukherjee (2007) used negotiation exercises to promote critical thinking skills of management students.

There is a tremendous amount of uncertainty in how to best assess critical thinking, both as a skill and as a learning outcome (Burbach et al., 2004; Williams, 1999). Most current critical thinking tests are paper-and-pencil exams, even though research has shown that critical thinking assessment should incorporate case studies, projects, group discussions, and simulations that draw on material from multiple courses (McEwen, 1994), should involve real-world activities (Williams, 1999), and should be problem-based (Pithers & Soden, 2000). Research has also shown that the critical thinking assessment process should include a variety of assessment techniques and settings (Halpern, 1998; McEwen, 1994).

Taking all of this information into consideration, we have developed a multimeasure, multiperiod assessment process of critical thinking to help our students develop critical thinking skills and to provide assessment data for curriculum development purposes.

Assessing critical thinking using simulated behavioral exercises

To assess critical thinking across multiple, realistic situations, we instituted an assessment center process. Assessment centers are well suited to assessing skills and abilities required by many college curriculums and are better suited to assessing skills than paper-and-pencil exams (Riggio, Aguirre, Mayes, Belloli, & Kubiak, 1997). Assessment centers provide multiple benefits, including providing the institution with detailed feedback on their students' performance for curriculum development purposes and providing students with specific feedback to be used for personal development (Riggio et al., 1997).

We defined critical thinking as a three-step process. First, critical thinking was defined simply as the ability to identify relevant facts, to identify and analyze options, and to reach an appropriate final decision. The second step was to identify specific critical thinking–related behaviors that were amenable to observation in an assessment center setting and to organize them into classifications.

We identified four behavior classifications that we want to assess. These are (a) issue identification, (b) information gathering, (c) option exploration, and (d) reaching a final decision. Issue identification involves skills such as identifying key issues, identifying urgent matters, following directions, and paying attention to details. It involves evaluating assumptions and explaining why an issue is important. Information gathering involves the skills of asking questions, adding comments, and seeking clarification. It also includes seeking input from others and evaluating credibility of others. Option exploration involves identifying alternative approaches and discussing the pros and cons of each approach. In addition, it includes evaluating an implemented decision and having an alternative plan. Finally, reaching a final decision involves synthesis of all the information into a sound decision. This behavior also includes being able to justify the decision and properly planning the implementation of the decision.

The final step in defining critical thinking was to operationalize these behaviors for each particular exercise. Here, the key issues that we wanted the students to address for each exercise were identified. In assessing a student's behavior, raters evaluate each of the four critical thinking behaviors for each of the seven exercises (discussed subsequently). Performance on the four behaviors, we believe, gives us a basic assessment of each student's overall critical thinking abilities.

As part of the assessment process, students are placed into realistic, work-related assessment center exercises to assess a variety of skills, including critical thinking. Students complete seven time-pressured

exercises that involve very different situations. The following are the exercises and tasks involved in each exercise:

1. *Case Analysis 1* – Students are presented with a business problem that involves a financial impact issue. They must analyze the issue, including financial data, and make a final recommendation.
2. *Case Analysis 2* – Students are presented with a business problem that involves a cultural diversity issue. They must analyze the issue, identify the diversity issue, and make a final recommendation.
3. *Client Meeting* – Students interact with an upset client. The client is right in front of them and is demanding action. The student must quickly determine the course of action that is appropriate for the organization as well as the client.
4. *Project Meeting* – Students interact with an employee to conduct a follow-up meeting for a project. Although the setting is a low-key meeting, the outcome has serious implications for the student's "career."
5. *Employee Meeting* – Students interact with a problem employee and must deal with a client complaint. The student must determine the proper course of action for dealing with the employee.
6. *Presentation* – Students present their solution to a departmental problem and are asked questions during the presentation. Because most students are not comfortable with public speaking, this exercise requires them to think critically when they are nervous.
7. *Group Meeting* – Students work together on a business problem. They have to work together as a group and come to a consensus on how to proceed.

We have instituted an assessment of critical thinking that breaks down an extremely complex skill into workable, assessable units and that utilizes multiple measures, multiple settings, and draws on multiple courses. We have incorporated cases, projects, group work, real-world simulations, and problem-based exercises. Students complete the Assessment Center at the freshman/sophomore level and at the junior/senior level. During the two intervening years, students take a number of courses, including the core courses in functional areas such as marketing and accounting, which help them sharpen their critical thinking skills. In particular, a specific course on critical thinking exposes them to the concepts of critical thinking. Hence, we expect an improvement in their critical thinking abilities. We, therefore, tested the following hypothesis: The critical thinking abilities of seniors/juniors would be significantly better than those of the freshmen/sophomores.

Method

Description of critical thinking exercises

A total of 94 students were tested during 2013–2014 academic year. The students were administered seven exercises which had to be completed within four hours. All exercises took place in a simulated, realistic work-related environment. Two were case analysis exercises, which resulted in the generation of Word documents, and five were role-play exercises, which were videotaped. The documents and videotapes were used for assessment purposes.

The first case involved a business problem that impacted the finances of the company. The students had to analyze the issues, perform a financial analysis using the financial data presented, and make a recommendation. The second case involved a business problem that impacted the cultural diversity at the workplace. Here, the students had to analyze the issue, identify the cause of the problem, and make a recommendation.

In the first role-play exercise, students had to interact with an upset client who was demanding immediate action. They had to determine a course of action that was mutually beneficial to both the client and the organization. In the second scenario, the students had to interact with an employee to follow up on the status of a project. Here, students were expected to make a decision that met the organizational goals and protects their career. In the third scenario, students had to interact with a problem employee. They were presented with a subperforming employee and a client complaint about that employee. The student was expected to take the proper course of action to protect the client, the organization and the employee. In the fourth scenario, students prepared and delivered a presentation describing their solutions to a departmental problem. Here, they were required to think critically and quickly under stress. Last, but not least, students were required to work together as a group on a work-related problem. They had to arrive at a consensus on the solution and determine what steps they would take to resolve the issue.

Data coding

Students were evaluated by a team of assessors randomly selected from a pool of trained raters. Raters were recruited from across the country and possess a variety of experiences. They came from all walks of life, and included graduate students, managers and executives, and business owners.

Chosen raters complete a training program that introduces the Assessment Center process, sources of rater bias, the assessment instrument, and the exercise materials. The training program stresses the importance of using only observable behaviors to evaluate student performance. The assessment instrument was designed to minimize the risk of bias between raters. The form consists of two parts: criteria and scale. Specific criteria for the following assessment items were established for each exercise:

- Effectively identifies and explains key issues
- Gathers needed information
- Identifies various options and analyses the pros and cons of each option
- Handles the situation appropriately
- Correctly calculates the financial impact of the decision on the organization
- Identifies all data necessary for an accurate calculation
- States additional information that may impact the decision
- Properly integrates all appropriate data into a final recommendation

For the "effectively identifies and explains key issues" item, for example, the case exercise issues are different than the key issues for the client exercise, and so on. To minimize the subjectivity of the instrument, the key issues for each exercise were predetermined. The raters merely identified whether or not the student touched on the specified key issues.

Once the rater determined which criteria were met, they would complete the scale portion of the instrument. The scale consisted of performance statements related to the criteria. For example, a scale item may read

- Did not meet any of the criteria
- Met one of the criteria
- Met two of the criteria
- Met all of the criteria

Raters did not determine the student's actual score. They selected the scale item that corresponded with the student's performance on the criteria. Scores were automatically entered based on the scale item chosen (0 = did not meet any, 3 = met all). This process minimized the risk of raters with different experience levels judging performance differently.

As our school uses a three-level rubric (novice, competent, and accomplished) for assessment purposes, we regrouped the students into three categories using the following classification scheme: novice, 0–1; competent, 1.5–2; and accomplished, 2.5–3. Scores are earned in increments of 0.5 due to averaging of scores from two raters, therefore the novice category incorporates scores of 0, 0.5, and 1; the competent category includes scores of 1.5 and 2; and the accomplished category encompasses scores of 2.5 and 3. The assessment goal of our school is that no more than 20% of students should fall in the novice category.

Interrater reliability

We randomly selected two raters from a panel that consists of 33 raters. As a measure of the interrater reliability, we recorded the number of discrepancies each rater had with a partner on a given administration of the assessment exercises. For each rater, we counted the number of occasions when the discrepancies exceeded four. Eight raters exceeded the limit of four only once, one rater exceeded twice, two raters exceeded three times, and only one rater exceeded four times. These results gave us the confidence that the procedure we described previously was appropriate.

Results

Results of these analyses are compiled into Tables 1–10. Tables 1–8 present data on each evaluation criteria for two administrations of assessment exercises, once at the freshman/sophomore level (henceforth called Time 1) and once at the junior/senior level (henceforth called Time 2). Tables 9 and 10 present the data for those students who took the test on Time 1 and Time 2 during the period this research was conducted. These data enable us to test our stated hypothesis that juniors/seniors would demonstrate better critical thinking abilities than freshmen/sophomores.

Table 1 contains the results on the students' ability to effectively identify key issues. Results in this category are mixed. Performance exceeded our stated goal of 20% or less novice in all but one category (Case 1 for Time 2). In fact, many students performed

Table 1. Effectively identifies and explains key issues.

	Time 1							Time 2						
	Novice (0–1)		Competent (1.5–2)		Accomplished (2.5–3)		*n*	Novice (0–1)		Competent (1.5–2)		Accomplished (2.5–3)		*n*
Case 1	7	5%	127	87%	12	8%	146	6	13%	31	67%	9	20%	46
Case 2	15	16%	97	84%	34	23%	146	11	24%	34	74%	1	2%	46
Client	10	7%	125	91%	3	2%	138	0	0%	46	100%	0	0%	46
Project	9	6%	103	71%	33	23%	145	1	2%	12	26%	33	72%	46
Employee	6	4%	133	92%	6	4%	145	6	13%	35	76%	5	11%	46
Presentation	19	13%	117	81%	9	6%	145	2	4%	38	83%	6	13%	46

Table 2. Gathers needed information.

	Time 1							Time 2						
	Novice (0–1)		Competent (1.5–2)		Accomplished (2.5–3)		*n*	Novice (0–1)		Competent (1.5–2)		Accomplished (2.5–3)		*n*
Case 1	120	82%	20	14%	6	4%	146	18	39%	24	52%	4	9%	46
Case 2	92	63%	45	31%	9	6%	146	26	57%	16	35%	4	9%	46
Client	98	71%	35	25%	5	4%	138	33	72%	12	26%	1	2%	46
Project	92	63%	39	27%	14	40%	145	20	43%	17	37%	9	20%	46
Employee	115	79%	30	21%	0	0%	145	32	70%	12	26%	2	4%	46
Presentation	117	81%	27	18%	1	1%	145	43	93%	2	4%	1	2%	46

Table 3. Identifies various options and analyses the pros and cons of each option.

	Time 1							Time 2						
	Novice (0–1)		Competent (1.5–2)		Accomplished (2.5–3)		*n*	Novice (0–1)		Competent (1.5–2)		Accomplished (2.5–3)		*n*
Case 1	7	5%	117	80%	22	15%	146	3	7%	36	78%	7	15%	46
Case 2	23	16%	101	69%	22	15%	146	10	22%	35	76%	1	2%	46
Client	2	1%	106	77%	30	22%	138	0	0%	31	67%	15	33%	46
Project	10	7%	121	83%	14	10%	145	2	4%	38	83%	6	13%	46
Employee	26	18%	115	79%	4	3%	145	11	24%	34	74%	1	2%	46
Presentation	12	8%	114	79%	19	13%	145	9	20%	34	74%	3	6%	46

Table 4. Identifies various options and analyses the pros and cons of each option.

	Time 1							Time 2						
	Novice (0–1)		Competent (1.5–2)		Accomplished (2.5–3)		*n*	Novice (0–1)		Competent (1.5–2)		Accomplished (2.5–3)		*n*
Case 1	70	48%	61	42%	15	10%	146	8	17%	22	48%	16	35%	46
Case 2	75	51%	60	41%	11	8%	146	33	72%	12	26%	1	2%	46
Client	43	31%	88	64%	7	5%	138	15	33%	23	50%	8	17%	46
Project	95	7%	30	83%	20	10%	145	13	28%	22	48%	11	24%	46
Employee	89	61%	51	35%	5	3%	145	22	48%	21	46%	3	7%	46
Presentation	88	61%	46	32%	11	8%	145	33	72%	12	26%	1	2%	46

Table 5. Correctly calculates the financial impact of the decision on the organization.

	Time 1				Time 2			
	Novice (0–1)	Competent (1.5–2)	Accomplished (2.5–3)	*n*	Novice (0–1)	Competent (1.5–2)	Accomplished (2.5–3)	*n*
Case 1	136	8	2	146	35	10	1	46
	93%	5%	1%		76%	22%	2%	
Presentation	143	0	2	145	41	2	3	46
	99%	0%	1%		89%	4%	7%	

Table 6. Identifies all data necessary for an accurate calculation.

	Time 1				Time 2			
	Novice (0–1)	Competent (1.5–2)	Accomplished (2.5–3)	*n*	Novice (0–1)	Competent (1.5–2)	Accomplished (2.5–3)	*n*
Case 1	60	83	3	146	4	47	1	46
	41%	57%	2%		9%	89%	2%	
Presentation	34	107	4	145	5	8	33	46
	23%	74%	3%		11%	17%	72%	

Table 7.

	Time 1				Time 2			
	Novice (0–1)	Competent (1.5–2)	Accomplished (2.5–3)	*n*	Novice (0–1)	Competent (1.5–2)	Accomplished (2.5–3)	*n*
Case 1	138	6	2	146	36	10	0	46
	95%	4%	1%		78%	22%	0%	
Presentation	136	8	1	145	45	1	0	46
	94%	5%	1%		98%	2%	0%	

Table 8.

	Time 1				Time 2			
	Novice (0–1)	Competent (1.5–2)	Accomplished (2.5–3)	*n*	Novice (0–1)	Competent (1.5–2)	Accomplished (2.5–3)	*n*
Case 1	137	7	2	146	38	8	0	46
	94%	5%	1%		83%	17%	0%	
Presentation	141	4	0	145	45	0	1	46
	97%	3%	0%		98%	0%	2%	

Table 9. Comparison of critical thinking scores from Time 1 to Time 2.

Student	Time	Case	*F*	Client	*F*	Project	*F*	Presentation	*F*	Employee	*F*
1	1	2	18.43**	4	7.14*	5	24.49**	2	7.92**	3	6.63*
	2	11		5		9		4		3	
2	1	4		5		2		1		2	
	2	8		8		11		0		8	
3	1	5		5		1		1		4	
	2	10		7		9.5		4		9	
4	1	5		2		2		2		2	
	2	3		7		8		8		10	
5	1	5		5		2		3		5	
	2	6		5		5		8		4	
6	1	1		4		3		2		3	
	2	8		6		11		4		6	
7	1	3		4		3		4		5	
	2	1		7		6		8		3	
8	1	1		5		5		0		1	
	2	7		6		7		6		7	
9	1	2		5		1		0		1	
	2	6		8		3		6		4	
10	1	1		5		2		0		4	
	2	2		5		5		2		8	
11	1	2		4		4		0		3	
	2	12		8		8		8		4	
12	1	0		6.5		1		3		5	
	2	4		6.5		5		4.5		6	
13	1	3		8		5		6		5	
	2	0		6		4		2		4	
14	1	3		8		3		5		10	
	2	8		6		3		4		9	
15	1	3		7		0		8		9	
	2	7		9.5		9		7		8	
16	1	5		3		7		3		4	
	2	12		6		9		8		5	
17	1	6		6.5		6.5		6.5		6	
	2	8		6		6.5		6		7.5	
18	1	6		7.5		10.5		8.5		7	
	2	10.5		6		11		6		6	

*$p < .05$. **$p < .01$.

remarkably better in Time 2 than in Time 1, as exemplified by the high percentages of accomplished in a number of exercises (Case 1, Project and Presentation). Unfortunately, if we concentrate on the novice category, there is an apparent drop in performance from Time 1 to Time 2 in three instances (Case 1, Case 2 and Employee).

Table 2 contains results on the students' ability to gather information necessary for making the appropriate decision. Most of the students did not do well in this category. At Time 1, there are no exercises in which the accomplished goal of 20% or the competent goal of 60% was achieved. At Time 2, there was only one category that met the accomplished goal (project). In comparing performance from Time 1 to Time 2, there is a noticeable improvement in performance on Case 1, project meeting, and employee meeting. Performance was noticeably worse in only the presentation exercise.

Table 3 shows the results on the students' ability to identify various options and analyze the pros and cons of each option. Students performed well in this category. Although the accomplished goal of 20% was met only twice (Time 1: client; Time 2: client), the novice goal of less than 20% was met in all but three of the categories (Time 2: Case 2, employee, and presentation). Unfortunately, performance did not necessarily improve between Time 1 and Time 2. We find a markedly greater number of novice scores in Case 2, employee meeting, and presentation exercises.

Table 4 shows the results on the student's ability to handle the situation appropriately. Results in this section are both problematic and positive. Overall, an unacceptably high number of students fell in the novice category at both Time 1 and Time 2. In fact, the novice category was below 20% only twice (Time 1: project; Time 2: Case 1).

Tables 5–8 show the results of the assessment of financial impact analysis skills. Unlike the previous learning outcomes, this outcome is assessed with only two exercises: Case 1 and presentation. Most of the students performed poorly in this category. For all four items of the financial analysis, a large number of students fell in the novice category, both at Time 1 and Time 2. Very few students demonstrated performance at the accomplished level, with the 20% goal

Table 10. Comparison of critical thinking scores across all five exercises.

Student	Average Time 1	Average Time 2	Difference	*F*	Student	Average Time 1	Average Time 2	Difference	*F*
1	3.2	6.4	3.2	28.35***	10	2.4	4.4	2	28.35*
2	2.8	7	4.2		11	2.6	8	5.4	
3	3.2	7.9	4.7		12	3.1	5.2	2.1	
4	2.6	7.2	4.6		13	5.4	3.2	−2.2	
5	4	5.6	1.6		14	5.8	6	0.2	
6	2.6	7	4.4		15	5.4	8.1	2.7	
7	3.8	5	1.2		16	4.4	8	3.6	
8	2.4	6.6	4.2		17	6.3	6.8	0.5	
9	1.8	5.4	3.6		18	7.9	7.9	0	

***$p < .001$.

being achieved only once (Time 2: presentation). Although it is encouraging that students at Time 2 showed improvement on some of the items, these results are somewhat alarming. It is evident that our students need more help with applying accounting and financial concepts to real-world problems. As a remedial measure, the school decided to offer tutoring to all students for the 200-level accounting classes to help them improve their skills in financial analysis.

Tables 9 and 10 provide longitudinal data on 18 students who have completed the Assessment Center twice, first at the Time 1 level and again at the Time 2 level. Scores are presented as average scores across all four critical thinking items, which changed the data to a 0–12 scale. Of these 18 students, 14 showed improvement between Time 1 and Time 2. Nine showed an improvement of 3–5 points, five showed an improvement of 1–2 points, three showed no improvement, and one showed a decrease in performance.

We also performed a within-subjects analysis of variance. Results are provided in Tables 9 and 10. Overall, students performed significantly better in Time 2 than in Time 1, $F(17) = 28.35$. In fact, they performed significantly better in all five individual exercises, $F(17) = 18.43$; client, $F(17) = 7.14$; project, $F(17) = 24.49$; presentation, $F(17) = 7.92$; and employee, $F(17) = 6.63$. These results support the hypothesis.

Implications

Results from our study have several implications about the assessment of critical thinking. It is evident that student performances vary from one critical thinking exercise to another. For example, Table 9 shows that Student 1 in Time 1 performs much better in exercises dealing with project and client than in the exercises involving case, presentation, and employee. Hence, this portfolio approach identifies the strengths and weaknesses of individual students. Student advisors can then advise individual students on what additional measures they should take. For example, advisors may suggest individual students to take additional courses, attend workshops or tutorial sessions on a particular topic. As our assessment center exercises require each student to complete the exercises twice, it is possible to monitor the progress made by each student from Time 1 to Time 2.

Our study, however, has several limitations. The sample size was small, particularly for the Time 2 group. Our Assessment Center has been operational only since 2006, hence we had limited time to develop a large database. Also, we modified several exercises because the results from preliminary runs indicated problems in validity and reliability. We have settled on the current set of exercises from 2009. We expect to develop a larger assessment database within the next three years. We also face challenges in ensuring that students take approximately 2 years' worth of course work before they undertake the assessment exercises the second time. Our students are free to register online. Therefore, they can potentially take the two courses (X200 and X410) which we use to administer the assessment exercises within one year or less against the advice of their academic advisors. We also receive several transfer students from other institutions who join at an advanced level. They may take X220 and X410 within a short span to graduate in time.

Conclusion

Despite the limitations and challenges mentioned previously, the present study offers a unique perspective on how to assess critical thinking of business students with the help of multiple measures, including individual and group exercises, and case analysis. We are also able to demonstrate significant improvement in our students' critical thinking abilities as they progress through our program. This is a unique feature of our assessment method. To our knowledge, no other

business school is using this approach to assess critical thinking on multiple occasions during the program. It is our hope that more business schools will be encouraged to develop additional measures of critical thinking. This will help in improving the teaching and learning of critical thinking—a critical skill to acquire for all business students.

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